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Title: Determination of the Eutectic Composition in NaCl + MgCl<sub>2</sub>

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# Determination of the Eutectic Composition in NaCl + MgCl<sub>2</sub>

SCOTT PARKER, SHANE MANN, MATT JACKSON, MARISA MONREAL

The available literature:

## References:

- [1] A. Kiswa, J. Kazmierczak, B. Borresen, G. M. Haarberg, R. Tunold J. Electrochem. Soc., Vol 144, No 5 (1997).
- [2] J. Wang, C. Zhang, Z. Li, H. Zhou, J. He, J. Yu, Sol. Energy Mater. Sol. Cells Vol 164 146-155 (2017).
- [3] M. Mohamedi ECS Proceedings Vol 1996-7 189 (1996).
- [4] O. Benes, R. J. M. Konings J. Nucl. Mater. Vol 375 202-208 (2008).
- [5] P. Chartrand, A. D. Pelton, Met. Mater. Trans. A Vol 32A 1361 2001
- [6] T. Xu, X. Li, L. Guo, F. Wang, Z. Tang, Sol. Energy Vol 209 568-575 (2020).

## \*Papers which study “NaCl-MgCl<sub>2</sub> Eutectic” but do not state a composition:

- A. Kiswa, J. Kazmierczak, B. Borresen, G. M. Haarberg, R. Tunold J. Electrochem. Soc., Vol 144, No 5 (1997).
- B. Liu, et al, Sol. Energy Mater. Sol. Cells Vol 170 77-86 (2017).
- D. E. Neil et al, J. Chem. Eng. Data Vol 10, No. 1, (1965).
- L. Guo, et al, Corros. Sci. Vol 166 108473 (2020).
- O. Benes, R. J. M. Konings J. Nucl. Mater. Vol 375 202-208 (2008).
- P. Chartrand, A. D. Pelton, Met. Mater. Trans. A Vol 32A 1361 2001

**Source:** [1] A. Kiswa, J. Kazmierczak, B. Borresen, G. M. Haarberg, R. Tunold J. Electrochem. Soc., Vol 144, No 5 (1997)

Eutectic composition is not stated. Graphically, it is assumed to be ~41%, with an associated melt point of 450 °C.

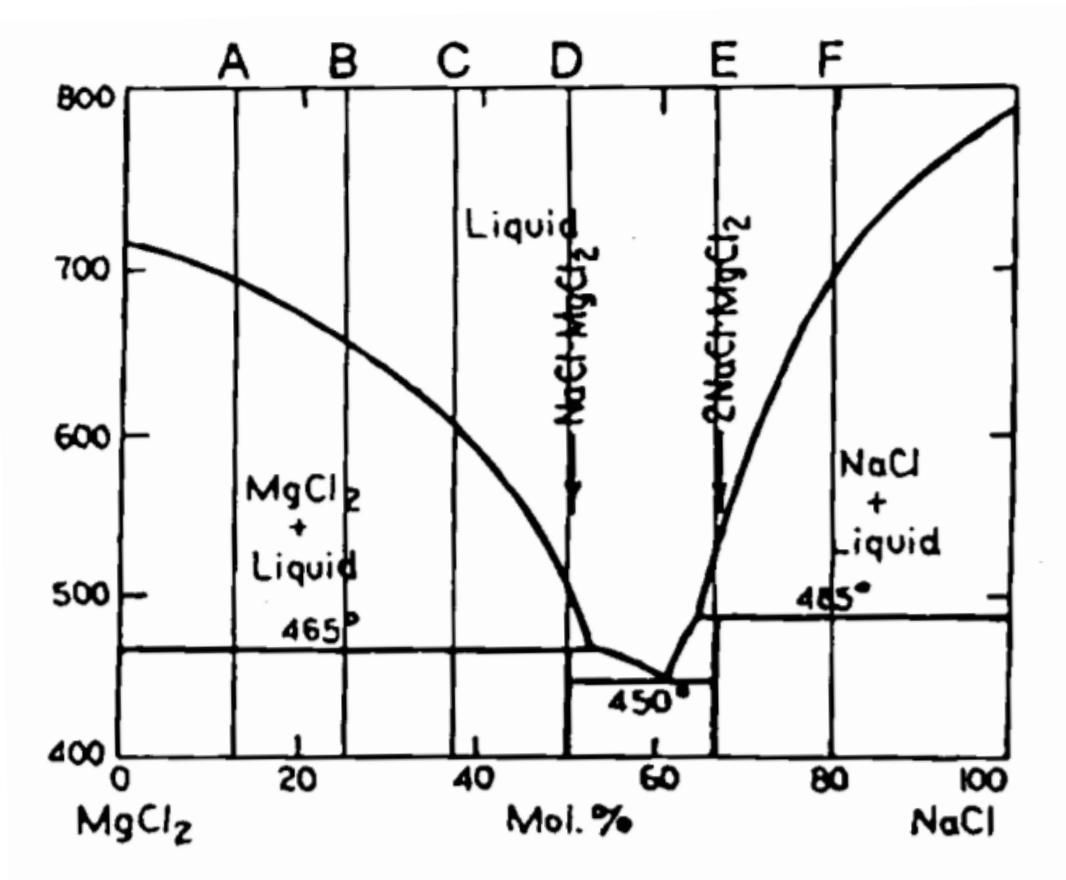


Fig. 2. The MgCl<sub>2</sub>-NaCl phase diagram with the compositions of the melts studied.

**Source:** [5] P. Chartrand, A. D. Pelton, Met. Mater. Trans. A Vol 32A 1361 2001

Eutectic composition is not stated. It is approximated graphically as 0.41 mol fraction MgCl<sub>2</sub>. A calculated eutectic temperature of 459 °C is stated, however the authors note that the experimental values fall between 430 °C and 450 °C.

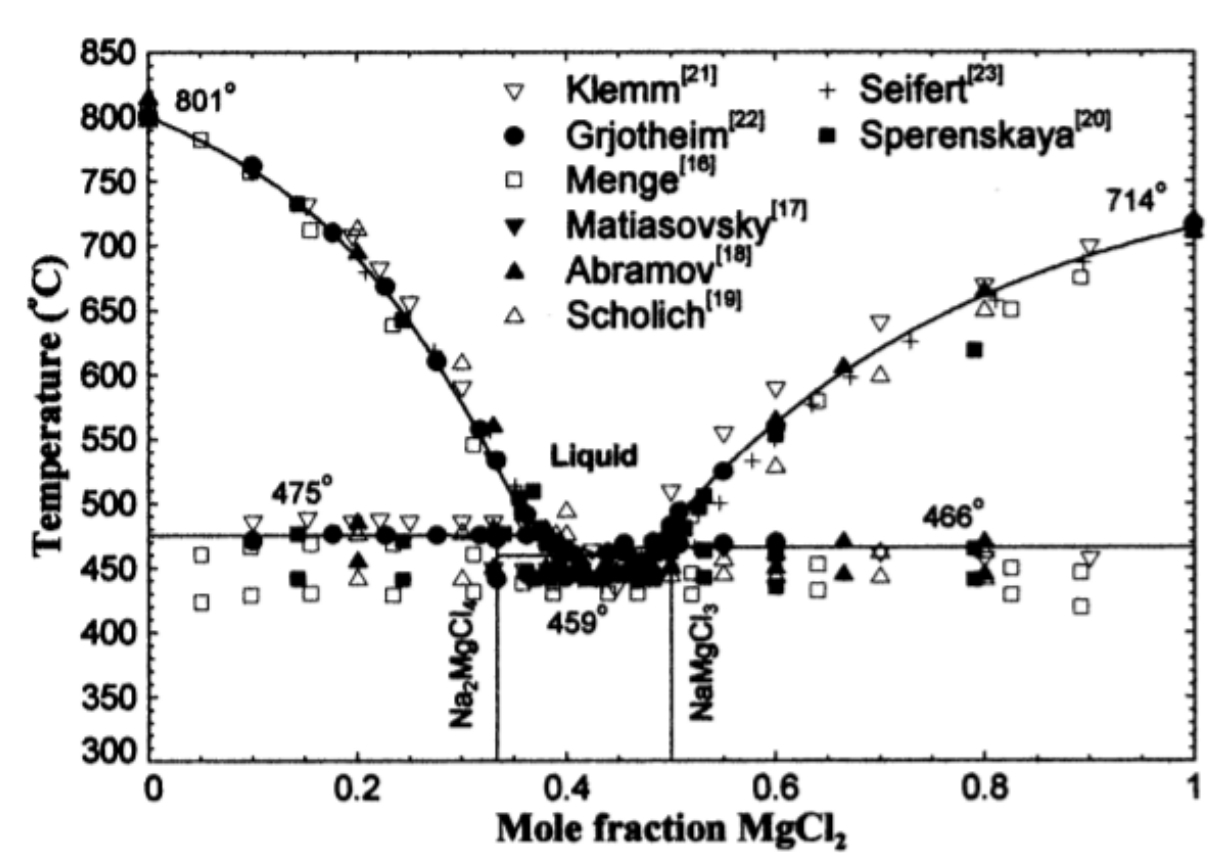


Fig. 5—NaCl-MgCl<sub>2</sub> system: calculated phase diagram.

**Source:** [2] J. Wang, C. Zhang, Z. Li, H. Zhou, J. He, J. Yu, Sol. Energy Mater. Sol. Cells Vol 164 146-155 (2017).

Stated eutectic is NaCl-52wt % MgCl<sub>2</sub> (i.e. 39.94 mol % MgCl<sub>2</sub>), with an associated melt point of 718 K (444.9 °C), and an enthalpy of fusion of 430 J/g.

**Source:** [3] M. Mohamedi ECS Proceedings Vol 1996-7 189 (1996)

Stated eutectic is NaCl-41.5 mol% MgCl<sub>2</sub> with an associated melt point of 445 °C.

**Source:** [4] O. Benes, R. J. M. Konings J. Nucl. Mater. Vol 375 202-208 (2008).

The eutectic composition is not stated, but the melt point is states to be 732 K (458.9 °C).

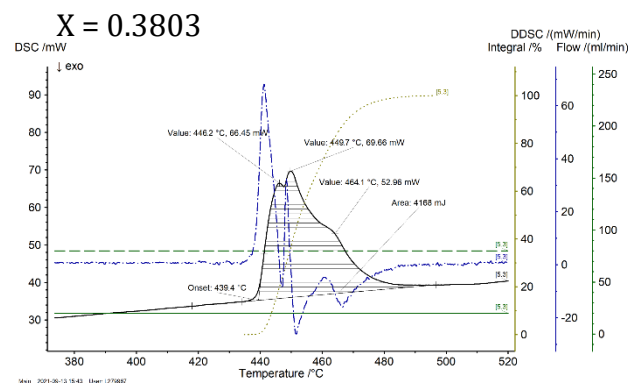
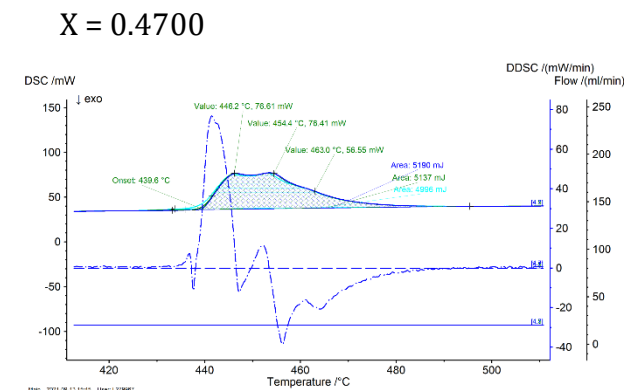
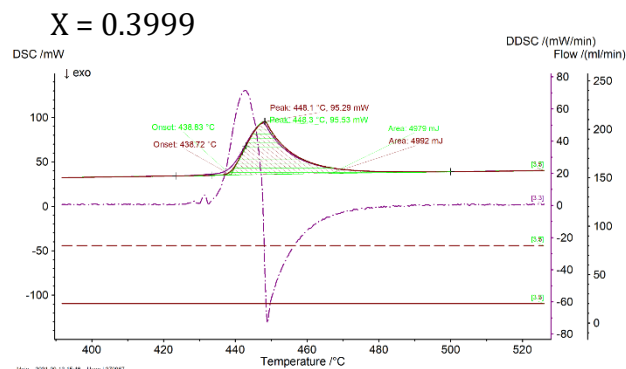
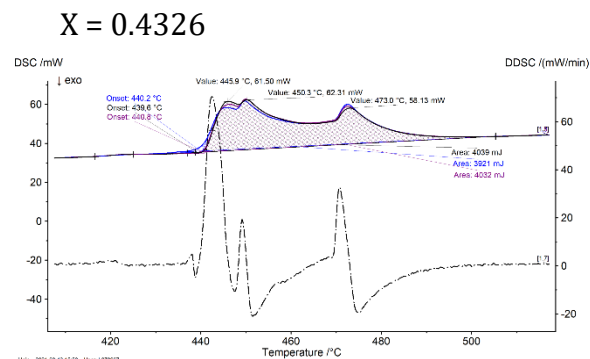
Interestingly, they state *“Because the simple eutectic systems were published earlier and are very well reproduced it is not necessary to show their figures in this work.”* Unfortunately, the work they refer to is not cited, nor is it apparently published elsewhere.

**Source:** [6] T. Xu, X. Li, L. Guo, F. Wang, Z. Tang, Sol. Energy Vol 209 568-575 (2020).

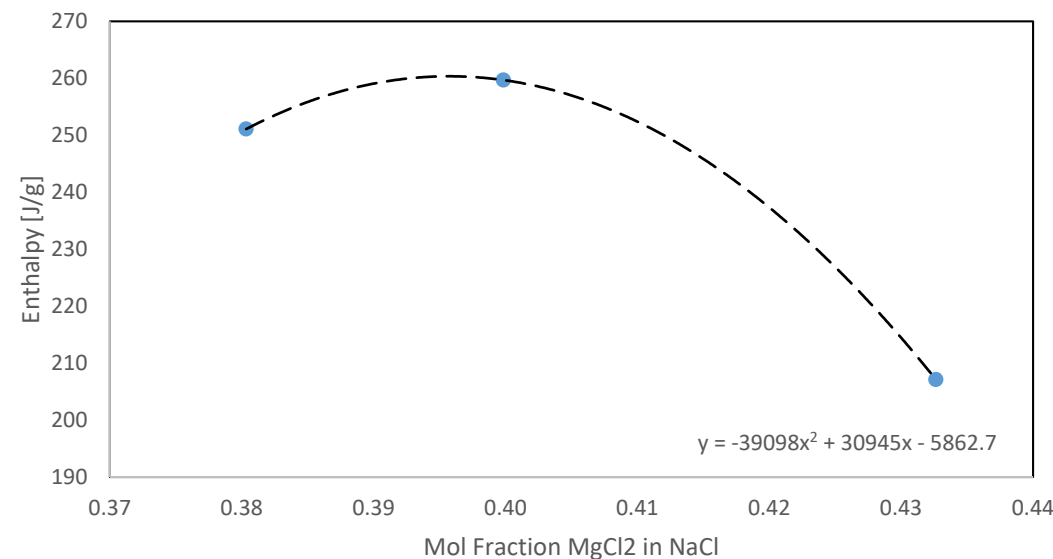
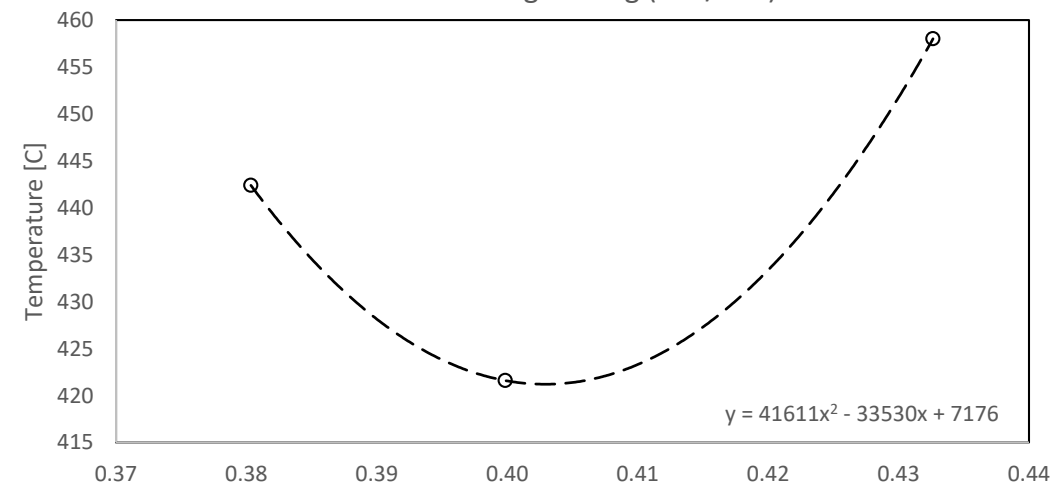
Stated eutectic is NaCl-42 mol% MgCl<sub>2</sub> with an associated melt point (extrapolated onset) of 710 K (436.9 °C) and enthalpy of fusion of 269.7 J/g (experimental) and 268.16 J/g (simulated).

# Recent Work

X = Mol Fraction  $\text{MgCl}_2$



Onset of solidification during cooling (10K/min)



- From melt onset (extrapolated onset) of 4 compositions,  $T_{\text{eutectic}} = 439.5$
- From minimization of onset during cooling at 10K/min, the eutectic composition is **0.4029** mol fraction  $\text{MgCl}_2$  in NaCl, and the enthalpy of fusion is **260 J/g**

Reference	Mol fraction $\text{MgCl}_2$	$T_{\text{eutectic}}$ [C]	Enthalpy of Fusion [J/g]
1*	0.41	450	-
2	.3994	444.9	430
3	.415	445	-
4*	0.41	448.9	-
5*	0.41	459	-
6	0.42	436.9	269.7
Average	0.41	447.5	-
2 X STDEV	0.0124	13.4	-
<i>This Work</i>	0.4029	$439.5 \pm 0.5$	$260 \pm 6$

\*Eutectic composition is estimated graphically